OFFICE OF
PREVENTION, PESTICIDES, AND
TOXIC SUBSTANCES

Note to Reader
August 7, 1998

Background: As part of its effort to involve the public in the implementation of the Food Quality Protection Act of 1996 (FQPA), which is designed to ensure that the United States continues to have the safest and most abundant food supply, EPA is undertaking an effort to open public dockets on the organophosphate pesticides. These dockets will make available to all interested parties documents that were developed as part of the U.S. Environmental Protection Agency's process for making reregistration eligibility decisions and tolerance reassessments consistent with FQPA. The dockets include preliminary health assessments and, where available, ecological risk assessments conducted by EPA, rebuttals or corrections to the risk assessments submitted by chemical registrants, and the Agency's response to the registrants' submissions.

The analyses contained in this docket are preliminary in nature and represent the information available to EPA at the time they were prepared. Additional information may have been submitted to EPA which has not yet been incorporated into these analyses, and registrants or others may be developing relevant information. It's common and appropriate that new information and analyses will be used to revise and refine the evaluations contained in these dockets to make them more comprehensive and realistic. The Agency cautions against premature conclusions based on these preliminary assessments and against any use of information contained in these documents out of their full context. Throughout this process, if unacceptable risks are identified, EPA will act to reduce or eliminate the risks.

There is a 60 day comment period in which the public and all interested parties are invited to submit comments on the information in this docket. Comments should directly relate to this organophosphate and to the information and issues available in the information in this docket. Once the comment period closes, EPA will review all comments and revise the risk assessments, as necessary.

These preliminary risk assessments represent an early stage in the process by which EPA is evaluating the regulatory requirements applicable to existing pesticides. Through this opportunity for notice and comment, the Agency hopes to advance the openness and scientific soundness underpinning its decisions. This process is designed to assure that America continues to enjoy the safest and most abundant food supply. Through implementation of EPA's tolerance reassessment program under the Food Quality Protection Act, the food supply will become even safer. Leading health experts recommend that all people eat a wide variety of foods, including at least five servings of fruits and vegetables a day.

Note: This sheet is provided to help the reader understand how refined and developed the pesticide file is as of the date prepared, what if any changes have occurred recently, and what new information, if any, is expected to be included in the analysis before decisions are made. **It is not meant to be a summary of all current information regarding the chemical.** Rather, the sheet provides some context to better understand the substantive material in the docket (RED chapters, registrant rebuttals, Agency responses to rebuttals, etc.) for this pesticide.

Further, in some cases, differences may be noted between the RED chapters and the Agency's comprehensive reports on the hazard identification information and safety factors for all organophosphates. In these cases, information in the comprehensive reports is the most current and will, barring the submission of more data that the Agency finds useful, be used in the risk assessments.

Jack Housenger, Acting Director
Special Review and Reregistration
Division

U. S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

March 9, 1998

MEMORANDUM

SUBJECT: EFED RED Chapter for **Isofenphos**
PC Code No. **109401**; Case No. **2345**
DP Bar codes D237285

TO: Ruby Whiters, Chemical Review Manager
Walt Waldrop, Branch Chief
RB III, Special Review and Reregistration Division (7508W)

FROM: Richard Lee, Biologist
Task Leader, Ecological Effects Assessment
Nelson Thurman, Environmental Engineer
Environmental Fate Assessment, Water Resources Assessment
ERB IV RED Team for Isofenphos
Environmental Fate and Effects Division (7507C)

THROUGH: Mah T. Shamim, Ph.D., Chief
Environmental Risk Branch IV / EFED (7507C)

This memo summarizes the attached EFED Environmental Risk Assessment (science chapter) for the isofenphos RED. It includes recommendations for labeling and mitigation measures and identifies gaps and uncertainties resulting from outstanding data requirements. The assessment identified the following major issues of concern:

- Isofenphos is persistent when used for the first time (enhanced biodegradation appears to reduce persistence in subsequent years of treatment).
- Both granular and emulsifiable concentrate formulations of isofenphos pose a high risk to terrestrial animals and aquatic invertebrates.
- Isofenphos has a high potential to reach surface waters by runoff and may persist in water.

The overall impact of isofenphos is likely to be reduced due to:

- an apparent susceptibility to enhanced degradation by soil microorganisms in subsequent years of application. Although we do not have adequate data to quantify the degree and extent of such degradation, we incorporated it qualitatively in our assessment.
- limited uses (primarily residential lawns and golf courses, with no food/feed crop uses) and limited acreage of use.

Use Characterization

The environmental risk assessment is based on the following use information for isofenphos:

- Isofenphos is an organophosphate insecticide registered for use on lawns, turf, ornamental shrubs and trees, commercial nurseries, fence-rows, and rights-of-way.
- Both granular and emulsifiable concentrate formulations, all applied with ground equipment, were considered.
- The pesticide is applied to a limited acreage nationally (approximately 132,000 acres); most of the product usage occurs on residential lawns and golf courses.
- The maximum single application rate is 2 lb. ai/acre; with two seasonal applications at a minimum 30 day interval, the maximum seasonal rate is 4 lb. ai/acre.
- Risks to nontarget organisms were evaluated for isofenphos use on lawns/turf (including golf courses), ornamental plants, and non-agricultural sites/drainage systems. Estimated drinking water concentrations were modeled with the lawn/turf usage.

Water Resources Assessment

The water resource assessment, based on the known fate properties of isofenphos along with limited monitoring data, concludes:

- While sufficiently persistent (with soil half-lives up to one year and field dissipation half-lives ranging from weeks to months), isofenphos is not likely to move appreciably through the soil to ground water, except in areas in which the ground water is particularly vulnerable (shallow depth to ground water, highly permeable soils with low adsorption capacities).
- Isofenphos can be expected to move to surface water via runoff. Available data suggest that isofenphos will persist once it reaches water. A significant portion of isofenphos residues will remain in the water column.
- Estimated concentrations of isofenphos in surface-water sources of drinking water (DWEC) were based on GENEEC due to inadequate monitoring data and the lack of a reliable Tier 2 scenario for use on golf courses and residential lawns. The DWECs -- 52 ug/L for acute risk and 37 ug/L for chronic risk -- exceed current drinking water levels of concern of 7-23 ug/L for acute exposure and 0.8-2.8 ug/L for chronic exposure to humans (communications with Paula Deschamps, HED, 1/12/98).
- For the reasons noted earlier (enhanced degradation in subsequent years of application and the nature and limited extent of usage), EFED believes, qualitatively, isofenphos is not likely to pose a significant risk to drinking water nationally. Any occurrences of isofenphos in water are likely to be localized in nature.

Ecological Risk Characterization

Available data indicate isofenphos is toxic to birds, mammals, beneficial insects, freshwater and estuarine/marine fish, and aquatic invertebrates. An evaluation of the potential risk to nontarget organisms from the use of isofenphos products, combining toxicity data with potential exposure, shows that acute and chronic levels of concern will be exceeded for terrestrial animals and aquatic invertebrates. Chronic levels of concern for freshwater and estuarine/marine fish are exceeded only for non-agricultural/ditch-drainage system uses. These levels of concern are exceeded for both granular and non-granular formulations.

Several factors suggest that the overall risk from isofenphos may be lower:

- While studies submitted by the registrant show isofenphos to be one of the more persistent organophosphates, other published studies suggest the persistence of isofenphos is diminished in subsequent years of application as adaptations by soil microorganisms lead to enhanced degradation. The extent to which enhanced degradation would reduce isofenphos exposure levels remains uncertain.
- The aquatic RQs are calculated based on Tier 1 GENEEC simulations (due to the lack of a suitable scenario for a Tier 2 model), which may overestimate exposure levels. However, risks to aquatic invertebrates may still be high.
- Isofenphos has no food/feed uses; existing uses (primarily lawns and golf courses) cover a limited acreage (approximately 132,000 acres treated nationally). It should be noted, however, that the limited use area may reduce overall risk nationally, but it does not preclude risk in the localized areas where the pesticide is used.
- Application recommendations on the existing label (1-2 applications in a season, wet-in, and ground rather than aerial application) can reduce off-target movement. Therefore, adverse effects on fish and wildlife will probably be less than estimated with the risk quotients, particularly when the recommended risk mitigation measures are considered.

The isofenphos oxon degradate is likely to be as toxic as isofenphos itself. While the data on persistence and fate of this degradate is sketchy, isofenphos oxon is the major degradate in the fate studies submitted to EFED. The extent to which isofenphos oxon will increase exceedances in the levels of concern cannot be fully quantified, but its presence does reduce the conservativeness in the risk quotients used to evaluate the risk from isofenphos in the environment. This oxon analog may also be susceptible to enhanced degradation.

Data Gaps

Environmental Fate: All environmental fate data requirements for isofenphos on non-food/feed uses have been satisfied. However, uncertainties still exist on the long-term persistence of isofenphos on soil, its persistence in aerobic aquatic environments, and the fate of the isofenphos oxon degradate.

- EFED does not have adequate data to quantify the extent of potential enhanced biodegradation often mentioned in scientific literature. A quantification of the extent and magnitude of enhanced degradation could be attempted by conducting aerobic soil metabolism studies (guideline 162-1) on a range of soils (preferably matched pairs of previously treated and untreated soils).
- Without an aerobic aquatic metabolism study (162-4), isofenphos is assumed to be stable in such environments.

- The persistence of the oxon analog of isofenphos cannot be quantified with existing data. Since this degradate is of apparent toxicological concern, estimates of environmental concentrations of the combined residues of isofenphos and isofenphos oxon were made using conservative fate data. If the registrant has a concern about the assumptions used, then additional data, particularly soil and aquatic metabolism studies, would be needed.

Ecological Effects: The ecological toxicity data base is complete except:

- an estuarine/marine invertebrate chronic toxicity data (72-4(b)). The study is required because both acute and chronic LOCs are exceeded for freshwater invertebrates and acute LOCs are exceeded for the estuarine/marine invertebrate.

The toxicity of the oxon analog of isofenphos is uncertain. An evaluation of the structure and a comparison with oxon analogs of other organophosphate pesticides (in particular, paraoxon, the oxon analog of parathion), suggest this degradate is at least as toxic as the parent. Therefore, lacking toxicity data, EFED assumes isofenphos oxon is as toxic as the parent isofenphos.

Risk Reduction

In addition to the label language proposed below, EFED recommends considering the following risk reduction measures to reduce risk to nontarget organisms from exposure to isofenphos. These measures are expected to reduce the overall risk, but not necessarily below the level of concern. It should be noted that qualitative and field evaluations of these reduction methods have not been completed. These recommendations may need to be upgraded in the future.

- An integrated pest management (IPM) plan could reduce the total volume of pesticide application, increase the effectiveness of the pest control, and potentially reduce the loss of efficacy due to enhanced biodegradation or possible development of insect resistance.
- Since one application is currently a common practice, the labeling should be amended to recommend one application, reducing the amount of pesticide applied.
- To reduce exposure to non-target terrestrial organisms, post-application irrigation (wetting in the pesticide) should occur immediately instead of within 24 hours. Also, subsoil application should be encouraged if possible.
- For isofenphos use adjacent to water bodies such as lakes, reservoirs, rivers, permanent streams, marshes or natural ponds, estuaries, and commercial fish ponds, a natural vegetative buffer strip (minimum 25-foot) will reduce adverse impacts to aquatic organisms.
- Risk of exposure to sensitive aquatic areas can also be reduced by avoiding applications when wind direction is toward the aquatic area.

EFED notes that, due to its risk to nontarget terrestrial animals and aquatic invertebrates, isofenphos is a candidate for restricted use classification.

Recommended Label Language

EFED recommends that the following language be included on the appropriate labels.

Statement to minimize the potential for surface water contamination for all end-use products:

> This chemical can contaminate surface water through ground spray applications. Under some conditions, it may also have a high potential for runoff into surface water after application. These include poorly draining or wet soils with readily visible slopes toward adjacent surface waters, frequently flooded areas, areas overlaying extremely shallow ground water, areas with in-field canals or ditches that drain to surface water, areas not separated from adjacent surface waters with vegetated filter strips, and areas overlaying tile drainage systems that drain to surface water.

Label statements for toxicity to nontarget organisms:

<u>Manufacturing Use Products</u>

> This pesticide is toxic to fish and wildlife. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries oceans or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

<u>End Use Products: Non-granular formulations</u>

> This pesticide is toxic to fish and wildlife. Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high-water mark. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwater or rinsate.

<u>End Use Products: Granular formulations</u>

> This pesticide is toxic to fish and wildlife. Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high-water mark. Runoff may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwater or rinsate.

Environmental Risk Branch IV (ERB IV) RED Team for Isofenphos

Richard Lee, Biologist
Task Leader, Ecological Effects Assessment
Nelson Thurman, Environmental Engineer
Environmental Fate Assessment, Water Resources Assessment

This chapter was peer-reviewed by Sid Abel, Environmental Scientist, Mike Rexrode, Biologist, and Dana Spatz, Chemist.

ENVIRONMENTAL RISK ASSESSMENT FOR ISOFENPHOS

ENVIRONMENTAL RISK ASSESSMENT

Use Characterization

Isofenphos is an organophosphate insecticide registered for use primarily on lawns/turf, ornamental plants, shrubs/trees and commercial nursery stock. No isofenphos end-use product is registered for food/feed use. OPP's REFS files list 39 active section 3 registrations (as of 8/4/97), with no 24C registrations. The 39 registrations consist of 36 granular formulations, 2 emulsifiable concentrate (EC) formulations and 1 technical product.

Approximately 132,000 acres were treated with isofenphos nationally. Most of the product use occurs on lawn care and golf courses, including residential lawn and home garden applications. Other use sites include fence rows, rights-of-way, drainage systems, and nursery potting soil. One EC formulation is a termiticide product pending cancellation at the request of the registrant. This use was not considered in the environmental risk assessment. None of the products are classified as a restricted use pesticide. A summary of the assessed use patterns, based on the product labels registered to Bayer Corporation, is listed below:

Table 1: Nonfood/nonfeed uses for isofenphos of concern in the environmental risk assessment.

Site Application Type Application equipment	Formulation G = Granular; EC = Emulsifiable Conc.	Max. Single Application Rate ai	Max. Seasonal Application Rate ai	Min. Interval between treatments (days)
Ornamental Areas (including ornamental beds)				
Broadcast application Ground equipment	5% G	2 lb/A	4 lb/A	30
Ornamental Nursery Stock				
Broad application Ground equipment	5% G or 22% EC (2 lb/gal)	2 lb/A	4 lb/A	30
Lawns and Turf (including Residential Lawns, Cemeteries, Golf Courses, Industrial Grounds, Parkways)				
Broadcast application Ground equipment	5% G	2 lb/A	4 lb/A	30
Chemigation Solid set irrigation system	22% EC (2 lb/gal)	2 lb/A	4 lb/A	30
Ornamental Trees				
Broadcast application Ground equipment	1.5% G	1.95 lb/A	3.9 lb/A	30
Uncultivated Nonagricultural Areas (including Drainage Systems, Fence Rows, Hedge Rows, Rights-of-Way)				
Broadcast application Ground equipment	5% G or 22% EC (2 lb/gal)	2 lb/A	4 lb/A	30

Isofenphos can be applied by a variety of methods and equipment, including broadcast, low pressure ground spray, chemigation, soil incorporation, mound drench, foam application, spot treatment, and soil mix and containerized plant treatment. Application can occur pre-plant, at planting, or as needed.

For golf courses, most of isofenphos products are used in the South and Southeast regions for control of mole crickets and chinch bugs on golf courses. Within this region, most of the products are applied in Florida, Texas, and Alabama. Large areas of Florida are susceptible to leaching and potential ground water contamination, which can lead to drinking water and ecological concerns. On the other hand, coastal Texas and Alabama may be more susceptible to surface runoff and contamination of water bodies, resulting in adverse aquatic ecosystem impacts. Similar concerns can be predicted in midAtlantic seaboard states, such as Virginia, New York, and New Jersey, where isofenphos is also used. Sporadic problems with surface water contamination can be found in the North-central region, especially in the states of Illinois and Ohio. A similar regional distribution of isofenphos usage and environmental concerns are found for residential uses.

Exposure Characterization

Isofenphos [1-methylethyl 2-[[ethoxy[(1-methylethyl)-amino]-phosphinothioyl]oxy] benzoate] is a neutral, non-polar organophosphorthioate insecticide with the following properties:

Molecular formula:	$C_{15}H_{24}NO_4PS$
Molecular weight:	345.39
Vapor pressure:	2.2×10^{-6} Torr
Water Solubility:	18 to 30 mg/L (ppm) at 20^{o} C
Octanol/Water Partition Coefficient:	Log $K_{ow} = 4.04$
Henry's Law Constant:	5.73×10^{-5} atm m^3 mol^{-1} (measured)

Appendix A shows the chemical structure for isofenphos and its major degradates.

a. Environmental Fate Assessment

Laboratory studies suggest potential persistence in aerobic soils (half-life of approximately one year). In field studies, isofenphos dissipated from the soil surface with half-lives of 7 to 81 days. Open scientific literature suggest that while isofenphos may be one of the more persistent organophosphate pesticides in the first year of application, soil microbial adaptations appear to enhance degradation and reduce persistence in subsequent years of use. According to available data, isofenphos may not degrade appreciably in water. Isofenphos appears to be marginally mobile -- it is unlikely to leach to ground water except in vulnerable areas but is expected to be available to move to surface waters via runoff. A major degradate, the oxygen analog of isofenphos (isofenphos oxon), appears to be more mobile and may also be persistent, although no pattern of decline was noted in the available studies. The following section summarizes the environmental fate and transport characteristics of isofenphos. A detailed discussion of the supporting fate studies can be found in Appendix B.

i. Degradation and Metabolism

The following characteristics of isofenphos, derived from laboratory studies, suggest persistence:

(1) isofenphos is stable to hydrolysis at pHs 5 and 7 and degrades slowly at pH 9 (half-life of 131 days);

(2) it is stable to photolysis in water but degraded on soil exposed to light with a half-life of 72 days (net rate corrected for degradation in the dark);

(3) isofenphos degrades slowly (half-life of 352 days) under aerobic soil conditions and is stable under anaerobic aquatic conditions.

Two additional supplemental aerobic soil metabolism studies reported half-lives of 69 and 127 days for isofenphos. However, the material balances in these studies failed to account for up to 69% of the applied radioactivity, so the half-lives are of questionable value and are not suitable for use in modeling. The lack of evidence for photolysis in water and the slow rate of photodegradation on soil may indicate that the "photolysis" rate reflects other degradative processes.

Numerous published studies suggest that, although isofenphos is persistent when first applied to soils, microbial adaptations enhance degradation in subsequent years.[1] In a week-long incubation study using 6 soils with a history of isofenphos use and 19 soils with no previous use, Racke and Coats (1990) found an increased rate of mineralization in the soils with previous use history ($35.9 \pm 2.4\%$ of the parent mineralized to CO_2) compared with the nonhistory soils ($2.4 \pm 1.0\%$). In a 4-week incubation study, they recovered 62.8% of the parent from a soil with no history of use and only 12.9% from a soil that was previously treated with isofenphos. Mineralization of the aromatic ring was evident; isofenphos oxon accumulated only in the nonhistory soil. Racke and Coats (1990) noted that other studies isolated isofenphos-degrading bacteria from soils with enhanced degradation, but not in nonhistory soils. Chapman and Harris (1990) found that repeated annual treatments of isofenphos increased the enhanced degradation activity in those soils. Enhanced degradation activity was still apparent in soils more than 162 weeks after the last treatment. Somasundaram and Coats (1990) reported that exposure of soil to salicylic acid, a secondary hydrolysis product, resulted in enhanced degradation of isofenphos. They cited literature that suggested that the formation of salicylic acid in soil may be a key factor in triggering the susceptibility of isofenphos to enhanced degradation. It is not clear whether the presence of other organophosphates may trigger enhanced degradation.

<u>Degradates/metabolites</u>: Isofenphos oxygen analog (also called isofenphos oxon) was identified

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[1] Evidence for enhanced degradation of isofenphos is obtained primarily from three chapters in ***Enhanced Biodegradation of Pesticides in the Environment***, ACS Symposium Series 426; KD Racke and JR Coats, editors; American Chemical Society, Washington, DC, 1990:

Racke, KD, and JR Coats. 1990. Enhanced Biodegradation of Insecticides in Midwestern Corn Soils. pp. 68-81.

Chapman, RA, and CR Harris. 1990. Enhanced Degradation of Insecticides in Soil: Factors Influencing the Development and Effects of Enhanced Microbial Activity. pp. 82-97.

Somasundaram, L, and JR Coats. 1990. Influence of pesticide metabolites on the development of enhanced biodegradation. pp. 128-140.

These chapters summarize new and previously-published work and refer to additional references that suggest enhanced degradation of isofenphos.

in the soil photolysis (increasing to 37% at the end of the 30-day study) and aerobic soil metabolism studies (increasing to 28% after 1 year); isopropyl salicylate was also detected in the soil photolysis study (peaking at 22%). Salicylic acid is a secondary hydrolysis product in soil. No pattern of decline was evident for either degradate. However, if both isofenphos and the structurally similar isofenphos oxon are considered together, the aerobic soil metabolism half-life is on the order of 3 years. As noted earlier, isofenphos oxon may also be susceptible to enhanced degradation in subsequent years of application.

ii. Mobility

In adsorption/desorption studies on four soils, isofenphos was marginally mobile, with Freundlich K_{ads} values of 5.8 to 10.1 and K_{oc} values of 663 to 1474 (average 972; lowest non-sand K_{oc} 663). The K_{ads} values were correlated with the organic carbon content of the soil ($r^2 = 0.76$). Isofenphos oxon was more mobile, with Freundlich K_{ads} values ranging from 1.5 to 3.9 and K_{oc} values from 150 to 308. Because the soils were sterilized and sterilization can modify soil adsorption properties, the quality of these studies is compromised, increasing uncertainty.

In an anaerobic aquatic metabolism study, the distribution of applied isofenphos residues increased from 30% to >60% in the pond water and decreased from 69% to <30% in the sediment after 1 year (isofenphos comprised 90% of the residues). This data suggests, at least in stagnant waters, a significant portion of applied isofenphos will remain in the water column.

iii. Field Dissipation

The results of four terrestrial dissipation studies suggest that isofenphos, applied as an emulsifiable concentrate formulation, may be less persistent in the field than the laboratory studies would indicate. However, low recoveries in these studies increase the level of uncertainty and may partially explain the variability in the results. In turf plots in Georgia and Minnesota and soil plots in Georgia and California, isofenphos dissipated from the upper 6 inches of soil with first-order half-lives of 7 to 81 days and DT_{50}s (the time in which 50% of the pesticide dissipates from the surface of the soil) ranging from 10 to 63 days. In California, a rapid initial dissipation ($t_{1/2}$ = 7 days) was followed by a plateau and a secondary dissipation half-life of >63 days. When both isofenphos and the structurally-similar oxon analog are considered together, the dissipation half-lives range from 21 to 170 days.

The studies only tracked isofenphos and the formation of its oxygen analog, but did not evaluate the formation of other degradates (including volatiles) or incorporation/ binding within the soil. The pesticide use history was unknown in the Georgia turf and soil plots. Isofenphos use was not reported in the previous 5 years on the other sites. Supplemental field studies covering 23 sites reported dissipation half-lives ranging from less than 2 weeks to more than 1 year, depending on factors such as formulation, location, and number of applications.

Field dissipation studies provide some indication on the potential mobility of isofenphos and its oxygen analog. Neither chemical was detected below 12 inches in the Georgia and Minnesota turf studies or below 6 inches in the Georgia bareground study. Isofenphos was detected to 18 inches and the oxygen analog to 30 inches in the California bareground study. The soils in the California study had a much lower organic matter content ($\leq$0.5%) than did the other three sites. The results suggest that while isofenphos is not highly mobile through the soil profile, under certain conditions it may move into the subsurface. Inferences of pesticide mobility from field dissipation study results have a high degree of uncertainty because the studies are not specifically designed to track leaching and the sampling methods (particularly compositing) may miss leaching pathways.

iv. Bioaccumulation

Isofenphos residues concentrate rapidly in fish tissue, reaching plateaus within 1 to 7 days after exposure. Maximum bioconcentration factors (BCF) were 94.5X (fillet), 469X (viscera), and 277X (whole body). Depuration was rapid, with 92% (fillet), 98% (viscera), and 97% (whole body) elimination of isofenphos residues after 14 days. Identified metabolites, accounting for 2 to 15% of the total radioactivity, were isopropyl salicylate glucuronide, isofenphos oxygen analog, hydroxy isofenphos glucuronide, isopropyl salicylate sulfate, and isopropyl salicylate.

v. Spray Drift

Isofenphos may be applied by ground spray equipment but not aerially. Spray drift is not likely to be a major route of dissipation and no specific ground spray drift studies were reviewed.

b. Terrestrial Exposure Assessment

Nongranular applications: The terrestrial exposure assessment is based on Hoerger and Kenaga (1972), as modified by Fletcher et al (1994)[2]. Terrestrial estimated environmental concentrations (EECs) for nongranular formulations (Table 2) were derived from maximum application rates (2 applications of 2 lb. ai/A each at 30 day intervals), incorporating dissipation rates for isofenphos. Uncertainties arise from a lack of data on interception and dissipation from foliar surfaces.

Granular applications: EECs for broadcast granular applications are calculated on the basis of mass (in mg) per area (square foot), corrected for the fraction of the pesticide left on the surface. For unincorporated broadcast applications, the entire fraction of the pesticide is assumed to remain on the surface.

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[2] Hoerger, F., and E.E. Kenaga. 1972. Pesticide residues on plants: Correlation of representative data as a basis for estimation of their magnitude in the environment. In F. Coulston and F. Korte, eds., *Environmental Quality and Safety: Chemistry, Toxicology, and Technology*, Georg Thieme Publ, Stuttgart, West Germany, pp. 9-28.

Fletcher, J.S., J.E. Nellessen, and T.G. Pfleeger. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants. Environ. Tox. Chem. 13:1383-1391.

Table 2: EECs on Avian and Mammalian Food Items From Applications of 1 lb ai/A and 2 x 2 lb ai/A With Dissipation Rates Included (from Hoerger & Kenaga, 1972, modified by Fletcher et al, 1994).

	Max. EEC (ppm) Residue for:		*Mean EEC (ppm) Residue for:*	
Food Items	*1 lb ai/A*	*2 x 2 lb ai/A*	*1 lb ai/A*	*2 x 2 lb ai/A*
Short grass	240	888	85	458
Tall grass	110	407	36	210
Broadleaf plants and small insects	135	500	45	258
Fruits, pods, seeds, and large insects	15	56	7	30

c. Water Resource Assessment

Although isofenphos is not likely to move appreciably through the soil to ground water, except in areas in which the ground water is particularly vulnerable (shallow depth to ground water, highly permeable soils with low adsorption capacities), it can be expected to move to surface waters via runoff. The chemical is sufficiently persistent (soil photolysis half-life of 72 days, aerobic soil metabolism half-life of up to 352 days, and field surface dissipation half-lives of up to 81 days) to be available for runoff for weeks to months after application, especially in areas where it is being used for the first time. In soils with a history of isofenphos use, persistence may be greatly reduced by enhanced biodegradation, reducing the potential for movement to water. Available data suggest that isofenphos will persist once it reaches water (no appreciable degradation was reported for photolysis in water, hydrolysis, and metabolism under anaerobic aquatic conditions). At least under anaerobic conditions, a significant portion of the isofenphos residues (predominantly the parent) will remain in the water column.

The oxygen analog of isofenphos appears to be more mobile than the parent and may also be persistent, although no pattern of decline was established in the available fate studies.

Limited water resource monitoring data (STORET, Pesticides in Ground Water Database) report few detects of isofenphos in water.

i. Ground Water Assessment

Adsorption/desorption studies (marginal mobility with K_{ads} of 6-10 and K_{oc} of 663 to 1474) and results of 3 of 4 field dissipation studies indicate the likelihood of isofenphos leaching to ground water is generally low. However, the potential exists for isofenphos to leach to ground water in high leaching potential areas, particularly those with a low organic matter content (e.g., low adsorption/retention capacity). Because isofenphos may degrade slowly (aerobic soil metabolism half-life of 352 days) below the soil surface, it may persist long enough to move to ground water in some instances (such as where the soils are permeable, the adsorption capacity is low, and/or the ground water is shallow).

Adsorption/desorption data and field dissipation studies suggest that isofenphos oxon may be more mobile than the parent. Although no data is specifically available on the persistence of this degradate, it accumulates over time in the laboratory studies, suggesting some persistence.

Monitoring Data: Ground-water monitoring data for isofenphos are limited. EPA's Pesticides in Ground Water Database reports isofenphos detections in 2 of 19 well samples in MA and 0 of 78 wells sampled in NY. The concentrations in the two detections in MA were 1.17 and 2.12 ug/L[3]. The quality of this data is uncertain since nothing is known about specific locations, uses or rates, or type of well or sample. STORET shows no detections of isofenphos (limits of detection ranging from 0.04 to 0.5 ug/L) in 1,040 ground-water monitoring samples taken between August 1989 and September 1996 in Florida. No sample depths (depth to ground water) were reported. No specific link was established between the well samples and specific isofenphos use areas.

Modeled Data: A preliminary ground water assessment was made using SCI-GROW[4] (Screening COncentrations In GROund Water) to estimate concentrations of pesticides in ground water under highly vulnerable conditions. SCI-GROW uses fate properties of the pesticide (aerobic soil half-life and sorption coefficients), the maximum application rate, and the existing body of data from small-scale ground-water monitoring studies. The model assumes the pesticide is applied at its maximum rate in areas where the ground water is particularly vulnerable to contamination. SCI-GROW is based on highly-vulnerable ground water that is believed to represent only a small percentage of drinking water in the pesticide use area. Because SCI-GROW is a regression model, it does not account for site-specific hydrology, soil properties, climatic conditions, or agronomic practices. Overestimates are particularly likely for foliarly-applied pesticides that are susceptible to photolysis or for volatile pesticides. As such, SCI-GROW is likely to provide high-end estimates of acute or chronic exposure and should be used only for screening purposes.

Isofenphos was modeled with a K_{oc} of 972 (mean value), an aerobic soil metabolism half-life of 352 days, and an application rate of 2 lb ai/A applied twice. SCI-GROW predicts that the ground water concentration for isofenphos is not expected to exceed 0.8 ug/L.

Because isofenphos oxon is structurally similar and is likely to be at least as toxic as the parent (see Ecological Effects Hazard Assessment), SCI-GROW was run for the combined isofenphos plus oxon residues. A K_{oc} of 230 (mean value for the more mobile moiety) and an aerobic soil metabolism half-life of 1,044 days for the combined residues were used, resulting in a ground water EEC of 22.8 ug/L for the combined isofenphos and isofenphos oxon residues. This modeled EEC contains a high degree of uncertainty because of uncertainties in the fate and persistence of isofenphos oxon. Neither modeled EEC accounts for potential enhanced degradation in subsequent years of use. It is likely that, even in vulnerable areas, the actual EECs will be lower when isofenphos is used in consecutive seasons.

ii. Surface Water Assessment

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3. Pesticides in Ground Water Database A Compilation of Monitoring Studies: 1971-1991 National Summary. Published in September 1992. EPA 734-12-92-001.

4 Barrett, M. 1997. SCI-GROW; "A proposed method to determine screening concentrations estimates for drinking water from ground water sources." Draft. USEPA/OPP/EFED, September 1997.

Isofenphos has the potential to move to surface waters, primarily via runoff. In some instances, drift from ground spray applications made near water bodies may also contribute to isofenphos contamination in surface waters. The chemical is sufficiently persistent (soil photolysis half-life of 72 days, aerobic soil metabolism half-life of 352 days, and field surface dissipation half-lives of up to 81 days) to be available for runoff weeks to months after application on soils where the pesticide is being applied for the first time. The persistence of isofenphos may be greatly reduced in subsequent years of application as microbial adaptations lead to enhanced degradation. The extent of enhanced degradation and the conditions under which it may occur is likely to vary, making it difficult to predict for modeling purposes.

Once isofenphos reaches surface waters, it is likely to persist. No appreciable degradation was reported for photolysis in water; the parent was stable to hydrolysis. In an anaerobic aquatic metabolism study, isofenphos was stable. After one year, 60% of the applied parent was associated with the water column, 30% with the sediment, and the remainder metabolized (primarily as volatiles). At least under anaerobic conditions, a significant portion of the isofenphos residues (predominantly the parent) will remain in the water column.

Isofenphos oxon is also likely to reach surface waters by runoff. Based on available data, runoff may be the major source of the oxon analog, with only small fractions of the degradate being produced from the degradation of isofenphos in water. Little is known about the persistence of this oxon analog in water.

Areas most susceptible to runoff contamination include poorly draining or wet soils with readily-visible slopes toward adjacent surface waters, fields with canals, ditches, or drains that empty into surface water, areas not separated from adjacent surface waters with vegetated filter strips, and highly erodible soils cultivated using poor agricultural practices.

Monitoring Data: The STORET database reported no detections of isofenphos in limited sediment and surface water samples taken in Florida, Illinois, and New York. In Florida, isofenphos was not detected (limits of detection ranging from 1.2 to 36 mg/kg, dry weight) in 68 sediment samples taken from lakes, estuaries, streams and outflows. No concentration was reported for one stream sample in Illinois. Isofenphos was not found above the limit of detection/quantification (0.03 to 0.5 ug/L) in 237 New York water samples (231 stream, 4 canal, and 2 lake samples). The utility of this data is uncertain because of the wide range in limits of detection and because no specific link was established between the water/sediment samples and specific isofenphos use areas.

Modeled Data: Preliminary (Tier 1) aquatic EECs are estimated using GENEEC, a screening model that provides an upper-bound estimate of EECs on a high exposure site. GENEEC uses basic environmental fate values (adsorption to soil, degradation in soil before runoff and in water) and pesticide label information (rates, intervals, incorporation, method of application) to estimate the EECs in a one-hectare, two-meter deep pond following the treatment of a 10 ha field. The runoff event occurs two days after the last application. The model accounts for direct deposition of spray drift onto the water body (assuming 1% for ground spray applications).

Isofenphos was modeled with a K_{oc} of 972 (mean value), an aerobic soil metabolism half-life of 352 days, and an application rate of 2 lb ai/A applied twice at a 30-day interval between applications. All other degradation rates (hydrolysis at pH 7, aqueous photolysis, aerobic aquatic metabolism) were considered stable. In addition, the combined residues of the parent and structurally-similar isofenphos oxon were modeled with a K_{oc} of 230 (mean value for the more mobile moiety) and an aerobic soil metabolism half-life of 1,044 days for the combined residues. Although this combined residue EEC was not used in the risk assessment, it does show that, when the toxic oxon is considered, aquatic risk quotients may be 2-3 times greater. Resulting EECs are shown in Table 3.

Table 3: Estimated Environmental Concentrations (EECs) For Aquatic Exposure from Aerial Application on Selected Uses Using GENEEC.

Site	*Formulation; Application Rate x No (Interval, da)*	*Peak EEC (ug/L)*	*4-day avg. EEC (ug/L)*	*21-day avg. EEC (ug/L)*	*56-day avg. EEC (ug/L)*
Turf/lawn	EC; 2 lb/A x 2 (30)	52	50	44	37
	G; 2 lb/A x 2 (30)	50	49	43	36
Combined Residues	2lb/A x 2 (30)	122	120	110	95

GENEEC is designed to provide a reasonable upper bound estimate of concentrations in water for ecological effects screening purposes. It assumes that essentially the whole 10-ha field receives an application of isofenphos at one time (in this case, two applications). The model pond is assumed to be static, with no outflow. Such a scenario may be reasonable in predicting screening-level concentrations in ponds found at a golf course. The applicability of such a scenario is less certain for residential lawns. Currently, EFED does not have Tier 2 screening models that adequately model runoff from golf courses or residential lawns.

iii. Drinking Water Assessment

Ground Water Sources: Because of uncertainty in the quality of the monitoring data (a maximum of 2.12 ug/L), both acute and chronic drinking water estimated concentrations (DWEC) from ground-water sources are based on the screening model SCI-GROW. DWECs for isofenphos are not expected to exceed 0.8 ug/L; DWECs for the combined isofenphos and oxon residues are not expected to exceed 22.8 ug/L.

Surface Water Sources: Insufficient monitoring data is available to provide estimates of isofenphos concentrations in surface water sources of drinking water. Surface water data reported in STORET is too limited in area (NY) and size (237 samples) to provide a reasonable estimate. No additional data is available. The only modeling data available for predicting estimated environmental concentrations of isofenphos in surface water comes from the preliminary screening model GENEEC. Given the use patterns, the turf scenario is best applicable to modeling for drinking water assessments. The following drinking water concentrations should therefore be used for screening purposes in the drinking water assessment:

Acute Drinking Water Estimated Concentration (DWEC) 52 ug/L

Chronic Drinking Water Estimated Concentration (DWEC) 37 ug/L

For the combined isofenphos and oxon residues, the acute DWEC is 122 ug/L and the chronic DWEC is 95 ug/L.

Several assumptions of the GENEEC model must be considered when using these DWECs in an assessment. Surface-water-source drinking water tends to come from bodies of water substantially larger than a one ha pond. While GENEEC assumes the pesticide is applied to the whole basin, basins large enough to support a drinking water utility are likely to include substantial areas that are not treated. Additionally, flow (in a river) or turn over (in a lake or reservoir) of the water is likely to occur in drinking water sources so the persistence of the chemicals near the drinking water utility intakes will be overestimated. Given these factors, the proper use of GENEEC for drinking water assessments is in providing screening concentrations on which to determine the need for further evaluation. If a risk assessment performed using GENEEC output does not exceed the level of concern, then one can be reasonably confident that the actual risk will not be exceeded. Exceedances in the level of concern from GENEEC estimates point to the need for better data (such as refined modeling, if possible, or monitoring studies specifically designed to relate water concentrations to usage) on which to make a decision.

The overall impact of isofenphos on potential drinking water sources is likely to be much less than what is estimated, particularly for surface water sources, for the following reasons:

- A limited use area (primarily residential lawns and golf courses) and limited acreage of use (approximately 132,000 acres nationally) are likely to result in isolated areas of concern. The uses tend to result in piecemeal treatment (i.e., not all lawns will be treated, nor will those treated be treated at the same time; greens and fairways, rather than the entire golf course, are likely to be treated), which would also reduce the total area treated in a watershed.
- The apparent susceptibility of isofenphos to enhanced degradation by soil microorganisms in subsequent years of application will reduce the length of time the chemical will be available for runoff or leaching, thus reducing the estimated environmental concentrations.

Currently, EFED does not have scenarios that adequately account for runoff from residential lawns or golf courses for use in PRZM-EXAMS, which is used for refined surface water modeling. We also do not have sufficient information to quantify the extent to which the factors above will reduce estimated drinking water concentrations. However, EFED believes that isofenphos is not likely to pose a significant risk to drinking water nationally. Any occurrences of isofenphos in water are likely to be localized in nature.

Ecological Effects Hazard Assessment

For acute exposure, isofenphos is slightly to very highly toxic to birds (LD_{50} = 8.7 mg/kg; LC_{50} > 1,000 ppm), moderately to highly toxic to small mammals (LD_{50} =28-127 mg/kg, rats), highly toxic to bees (LD_{50} = 0.05 µg/bee), moderately to very highly toxic to freshwater organisms (LC_{50}

= 0.039-1.8 ppm), and moderately to very highly toxic to estuarine/marine organisms (LC_{50} or EC_{50} = 1.7 ppb-1.6 ppm). Chronic toxicity studies established the following NOEC values and ecological endpoints affected: 10 ppm for birds (number of eggs laid/hatched and viable embryos); 1 ppm for small mammals (oncogenic response and ChE inhibition); 66 ppb for freshwater fish (larval growth and mortality); 0.22 ppb for freshwater invertebrates (larval growth and mortality). Appendix C summarizes individual toxicity studies and requirements.

a. Toxicity to Terrestrial Animals

i. Birds, Acute and Subacute

Isofenphos is highly toxic (mallard duck LD_{50} of 32 mg/kg) to very highly toxic (northern bobwhite quail LD_{50} of 8.7 mg/kg) to avian species on an acute oral basis. The guideline (71-1) is fulfilled (MRID 099080).

Isofenphos is slightly toxic (mallard duck 5-day LC_{50} of >1000 to 4908 ppm) to highly toxic (northern bobwhite quail 5-day LC_{50} of 145 ppm) to avian species on a subacute dietary basis. The guideline (71-2) is fulfilled (MRID 096659, 41901305).

ii. Birds, Chronic

Isofenphos can cause reproductive impairment to avian species at dietary level as low as 50 ppm (reduction in percent embryo hatch). The body weight was affected at >10 ppm in mallard duck study. Endpoints are shown in Table 4. The guideline requirements (71-4) are fulfilled (MRIDs 098035, 098036, 42347301, 42891701).

Table 4: Avian Reproduction

Species	% ai	NOEC/LOEC (ppm)	LOEC Endpoints	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	91.9	25/50	Reproductive success % hatch of embryo	098035; Beavers/81	Core
	91.4	50/100	Reproductive effects egg/ laid/hatched, viable embryo	42347301; Beavers et al. /92	Core
Mallard duck *(Anas platyrhynchos)*	92	NA/150 (LOEC)	Reproductive success 14-d old survivor of egg set & normal hatchling	098036; Beavers/81	Core
	91.4	10/75	Body weight	42891701; Beavers et al./92	Core

NA Not available

iii. Mammals, Acute and Chronic

Isofenphos is moderately toxic to highly toxic to mammals on an acute oral basis (LD_{50} of 28-38 mg/kg in laboratory rats and 91-127 in laboratory mice). In rat chronic studies, isofenphos caused a positive oncogenic response and ChE inhibition at >1 ppm. EFED has no guideline requirement for the mammalian toxicity study.

iv. Insects

Isofenphos is highly toxic to bees on an acute contact basis (LD_{50} of 0.05 ug/bee). The guideline (141-1) is fulfilled (MRID 42567701). A study of toxicity from residues on foliage, required because of the potential for exposure and the low acute contact LD_{50}, will be waived because the label caution based on the acute contact toxicity study will be adequate.

v. Terrestrial Field Testing

Avian Small Pen Study of Amaze 20 G with Bobwhite Quail (Carlisle & Carsel, 1982; Acc. # 248344): No evidence of mortality or other adverse effects from exposure to application of Amaze 20% Granules at up to 1.3 lb. a.i./acre was found. This study is scientifically sound and will support the requirement for a small pen field study on a wild upland game species.

Simulated Field Study with Amaze 5% Granular on Turf with Rabbits and Bobwhite Quail (Lamb, 1981; Acc. #31255-323): No effect to rabbits or quail were observed at 2 lb ai/ac rate.

b. Toxicity to Freshwater Aquatic Animals

i. Freshwater Fish, Acute

Isofenphos is moderately to freshwater fish (LC_{50} 1.4 - 10 ppm) on an acute basis. The results of multiple studies are shown in Table 5. The guideline (72-1) requirement for freshwater fish acute toxicity study is fulfilled (MRID 096659, 41901303, 41901304).

Table 5: Freshwater Fish Acute Toxicity

Species/ (Flow-through or Static)	% ai	96-hour LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)* static	92	1.8	Moderately toxic	096659; Nelson & Roney/77	Core
	91.8	3.3	Moderately toxic	41901304; Gagliano/91	Supplemental
	15	20	Slightly toxic	096659; Nelson & Roney/77	Supplemental
	72	2	Moderately toxic	096659; Nelson & Roney/77	Supplemental
Bluegill sunfish *(Lepomis macrochirus)*	92	1.4	Moderately toxic	096659; Nelson & Roney/77	Core
	91.8	2.2	Moderately toxic	41901303; Gagliano	Core
	15	15	Slightly toxic	096659; Nelson & Roney/77	Supplemental
	72	1.3	Moderately toxic	096659; Nelson & Roney/77	Supplemental
Channel catfish (*Ictalurus punctatus*)	92	2.1	Moderately toxic	096659; Nelson & Roney/77	Core

ii. Freshwater Fish, Chronic

Isofenphos significantly reduced larval survival and growth in rainbow trout (NOEC 66 ppb) and fathead minnows at concentrations greater than 130 ppb (LOEC). Results of several studies are shown in Table 6. The guideline (72-4) requirements for freshwater fish early life-stage chronic study is fulfilled (MRID 41909201).

Table 6: Freshwater Fish Early Life-Stage Toxicity Under Flow-through Conditions

Species	% ai	NOEC/LOEC (ppb)	MATC (ppb)	Endpoint Affected	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)*	91.9	153 >407	250	Larval mortality & growth	126777 Carlisle/Roney/83	Core
	91.9	NOEC=1563 (highest conc)	-	Hatching larval mortality	126775 Carlisle/Roney/83	Core
	91.9	66 206	117	Larval mortality	109276 Carlisle /82	Core
Fathead minnows *(Pimephales promelas)*	91.8	61 130	89	Growth (length)	41909201 Rhodes & Herzig/91	Core

MATC is the geometric mean of the NOEC and LOEC. NA Not available

A freshwater fish life-cycle test, required because the end-use product is expected to be transported to water from the intended use site and the EEC is greater than one-tenth of the NOEL in the fish early life-stage or invertebrate life-cycle test, will be waived because both freshwater fish acute high risk and chronic LOCs are not exceeded for all end uses except ornamental trees and non-agricultural/drainage ditches (for acute risk only).

iii. Freshwater Invertebrates, Acute

Isofenphos is very highly toxic to aquatic invertebrates (LC_{50}/EC_{50} of 3.9-4.6 ppb in three studies on *Daphnia magna*) on an acute basis. The guideline (72-2) requirement for freshwater invertebrates is fulfilled (MRID 099081, 096659, 41609908). The formulated product is also considered very highly toxic to freshwater aquatic invertebrates.

iv. Freshwater Invertebrate, Chronic

Isofenphos significantly reduced surviving offsprings in *Daphnia magna* at concentrations at or greater than 0.22 ppb. The guideline (72-4) requirement for freshwater invertebrate chronic study is fulfilled (MRID 43220002, 41609907).

c. Toxicity to Estuarine and Marine Animals

i. Estuarine and Marine Fish, Acute

With an LC_{50} of 1.66 ppm on sheepshead minnow, isofenphos is moderately toxic to estuarine/marine fish on an acute basis. The guideline (72-3a) is fulfilled (MRID 42321801).

ii. Estuarine and Marine Fish, Chronic

An estuarine/marine fish early life-cycle test, required because the end-use product is expected to be transported to water from the intended use site and the EEC is greater than one-tenth of reported LC_{50} or EC_{50} values, will be waived because both freshwater fish acute high risk and chronic LOCs are not exceeded for all end uses except ornamental trees and non-agricultural/ drainage ditches. For similar reasons, an estuarine/marine fish life-cycle test will also be waived.

iii. Estuarine and Marine Invertebrates, Acute

Isofenphos is highly toxic to very highly toxic to estuarine/marine invertebrates on an acute basis with LC_{50}/EC_{50} from 1.7 (mysid) to 152 ppb (eastern oyster). The guideline (72-3b and 72-3c) is fulfilled (MRID 416099-09,-10).

iv. Estuarine and Marine Invertebrate, Chronic

No estuarine/marine invertebrate toxicity study was submitted. The study is required because both acute and chronic effect levels of concerns are exceeded for freshwater invertebrates. The acute effect LOC for the estuarine/marine invertebrates is also exceeded.

d. Toxicity to Plants

Plant toxicity studies are not required for insecticides except on a case-by-case basis (e.g., label bears phytotoxicity warnings; incident data or literature suggest phytotoxicity). Since isofenphos does not carry phytotoxicity warnings on its labels, no plant toxicity studies are required.

e. Toxicity of Isofenphos Oxon[5]

The toxicity of the oxon analog of isofenphos is uncertain. An evaluation of the structure and a comparison with the oxon analogs of other organophosphate pesticides suggest this degradate is at least as toxic as the parent. Isofenphos is a phosphorothionate (parathion analogs) compound with a structure similar to parathion. These insecticides are nontoxic precursors of their corresponding oxidative phosphates (paraoxon in the case of parathion), which are the actual anticholinergic agents in animals and plants. All parathion analogs must first be activated *in vivo* to become toxic, and this reaction is carried out by an enzyme, mixed function oxidase (MFO) with cofactor NADPH and oxygen within animals and plants. In insects, phosphorothionates and their corresponding phosphates have similar LD_{50}s. Parathion and paraoxon resulted in the same LC_{50} value of 330 ppb in fathead minnow acute toxicity studies.

In soils, oxidative activation can occur through extracellular enzymes found outside living organisms, exoenzymes produced by living microorganisms, or enzymes released on the death of soil organisms. In general, soil organisms hydrolyze (via esterase) rather than oxidize the organophosphate insecticides, while fungi can dealkylate them, and yeast can reduce the nitro groups. Paraoxon is apparently not stable in the soil environment, hydrolyzing rapidly. However,

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[5] This evaluation is based on the following references:
Matsumura, F. 1975. Toxicology of Insecticides. Plenum Press (New York).
O'Brien, R.D. 1967. Pesticide: Action and Metabolism. Academic Press (New York).
O'Brien, R.D. 1960. Toxic Phosphorus Ester. Academic Press (New York).
Alexander, M. 1994. Biodegradation and Bioremediation. Academic Press (New York).
Brown, A.W.A. 1978. Ecology of Pesticides. Wiley-Interscience.

isofenphos oxon is found in the soil environment and may be more stable than paraoxon.

Lacking toxicity studies on isofenphos oxon, EFED assumes isofenphos oxon is as toxic as the parent isofenphos.

Ecological Risk Assessment

To evaluate the potential risk to nontarget organisms from the use of isofenphos products, risk quotients (RQs) are calculated from the ratio of estimated environmental concentrations (EECs) to ecotoxicity values. RQs are then compared with levels of concern (LOCs) for determination of potential risk and the consideration of regulatory action. Appendix D provides detailed RQ calculations.

a. Exposure and Risk to Nontarget Terrestrial Animals

Table 7 summarizes LOC exceedances for nontarget terrestrial animals.

Table 7: Summary of Level of Concern (LOC) Exceedances For Non-Target Terrestrial Animals from the Use of Products Containing Isofenphos.

Site/Appl. Meth./ Form./Rate (No app.)	Non-target Organism	Food items	Acute RQ	Chronic RQ
Turf/Chemigation EC/2 lb ai/A (2)	Birds (bobwhite quail, subacute; mallard duck, chronic)	Short grass	6.12***	88.80+
		Tall grass	2.81***	40.70+
		Forage/small insects	3.45***	50.00+
		Seeds	0.39**	5.60+
Turf/Broadcast Granular/2 lb ai (1)	Birds (bobwhite quail, subacute; mallard duck, chronic)	Granular	13.28 ***(LD_{50}/ft^2)	
		Granular	0.65 ***(LD_{50}/ft^2)	
Turf/Chemigation EC/2 lb ai/A (2)	Mammals (15 g) (Herbivore/Insectivore)	Short grass	32.57***	
		Forage / small insects	18.32***	
		Large insects	2.04***	
	Mammals (35 g) (Herbivore/Insectivore)	Short grass	22.63***	458+
		Forage / small insects	12.73***	210+
		Large insects	1.41***	258+
	Mammals (1000 g) (Herbivore/Insectivore)	Short grass	5.14***	
		Forage / small insects	2.89***	
		Large insects	0.32**	
Turf/Chemigation EC/2 lb ai/A (2)	Mammals (15 g) (Granivore/Insectivore)	Seeds	0.45**	
	Mammals (35 g) (Herbivore/Insectivore)	Seeds	0.32**	30+
	Mammals (1000 g) (Herbivore/Insectivore)	Seeds	0.06	

Table 7: Summary of Level of Concern (LOC) Exceedances For Non-Target Terrestrial Animals from the Use of Products Containing Isofenphos.

Site/Appl. Meth./ Form./Rate (No app.)	Non-target Organism	Food items	Acute RQ	Chronic RQ
Turf/Ground Granular/2 lb ai (1)	Mammals (15 g)	Granular	49.52***	
	Mammals (35 g)	Granular	21.22***	
	Mammals (1000 g)	Granular	0.74***	

*** exceeds acute high risk, restricted use, and endangered species LOC
** exceeds acute high risk, restricted use LOC
+ exceeds chronic risk for reproduction effect

i. Birds

a. Non-granular Products

For a bobwhite quail LC_{50} of 145 ppm and a mallard duck NOEC of 10 ppm, multiple broadcast applications of nongranular isofenphos products on turf exceed avian acute high risk, acute restricted use, and acute endangered species levels of concern at current maximum application rates for all food items except seeds (for seeds, only acute restricted use and acute endangered species LOCs will be exceeded). The avian chronic level of concern is exceeded at current maximum application rates.

b. Granular Products

Birds may be exposed to granular pesticides through ingestion (such as foraging for food or grit or drinking water contaminated by granules) and dermal exposure (such as walking on exposed granules, bathing in pools, or dust-bathing). Based on the number of lethal doses (LD_{50}s) per square foot immediately after application ($LD_{50}s/ft^2$), broadcast applications of granular products on turf exceed avian acute high risk, restricted use, and endangered species levels of concern for waterfowls and upland game birds at current maximum application rates.

ii. Mammals

Risk quotients above are calculated for three weight classes of mammals (15, 35, and 1000 g), each presumed to consume four different kinds of food (grass, forage, insects, and seeds).

a. Non-granular Products

Multiple applications of nongranular products (RQs calculated using a rat LD_{50} of 28 mg/kg) exceed mammalian acute high risk, acute restricted use, and acute endangered species levels of concern for herbivore/insectivore mammals at current maximum application rates. For granivore mammals, only acute restricted use and acute endangered species LOCs are exceeded.

The mammalian chronic level of concern is exceeded at current maximum application rates for multiple broadcast applications of nongranular products on turf.

b. Granular products

Mammalian species also may be exposed to granular pesticides by ingestion or through dermal contact. The number of lethal doses (LD_{50}s) available within one square foot immediately after application is used as a risk quotient ($LD_{50}s/ft^2$) for the various types of exposure to bait pesticides.

Based on mammalian acute risk quotients for granular products on turf (using LD_{50}/ft^2 and rat LD_{50} of 28 mg/kg), mammalian acute high risk, acute restricted use, and acute endangered species levels of concern are exceeded at current maximum application rates. EFED does not have a standard procedure for assessing chronic risk to mammalian species for granular products.

iii. Insects

Currently, EFED does not assess risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions.

b. Exposure and Risk to Nontarget Freshwater Aquatic Animals

Table 8 summarizes the LOC exceedances for nontarget aquatic organisms.

Table 8: Summary of Level of concerns LOCs) Accedence for Non-Target Aquatic Animals from the Use of Products Containing Isofenphos

Site/Appl. Meth./ Formul./Rate (No appl.)	Non-target Organism	Acute RQ	Chronic RQ
Turf/Chemigation EC/2 lb ai/A (2)	Freshwater fish (Rainbow trout)	0.04	0.56
	Freshwater invertebrate (Daphnids)	13.33***	200+
	Estuarine/marine fish (Sheephead minnow)	0.03	0.61
	Estuarine/marine invertebrate (Mysid shrimp)	30.59***	
Turf/ornamental/ground Granular/2 lb ai/A (2)	Freshwater fish (Rainbow trout)	0.04	0.55
	Freshwater invertebrate (Daphnids)	12.82***	195.45+
	Estuarine/marine fish (Sheephead minnow)	0.03	0.59
	Estuarine/marine invertebrate (Mysid shrimp)	29.4***	
Non-Ag./drainage/ground Granular/2 lb ai/A (2)	Freshwater fish (Rainbow trout)	0.16**	2.51+
	Freshwater invertebrate (Daphnids)	58.97***	900+
	Estuarine/marine fish (Sheephead minnow)	0.14**	2.71+
	Estuarine/marine invertebrate (Mysid shrimp)	135.29***	

*** exceeds acute high risk, restricted use, and endangered species LOC
** exceeds acute high risk, restricted use LOC
+ exceeds chronic risk for reproduction effect

i. Freshwater Fish

The risk quotients for freshwater fish (using a rainbow trout LC_{50} of 1400 ppb and NOEC of 66 ppb) exceed acute restricted use, acute endangered species, and chronic risk levels of concern only with non-agriculture/drainage system end uses at current maximum application rates.

ii. Freshwater Invertebrates

Risk quotients for freshwater invertebrates (using a daphnid EC_{50}/LC_{50} of 3.9 ppb and LOEC of 0.22 ppb) exceed aquatic acute high risk, acute restricted use, acute endangered species, and chronic risk levels of concern at current maximum application rates.

c. Exposure and Risk to Estuarine and Marine Animals

Risk quotients for estuarine/marine fish (using a sheephead minnow LC_{50} of 1660 ppb and a sheephead minnow NOEC of 61 ppb) exceed acute restricted use, acute endangered species, and chronic levels of only with non-agricultural/drainage system use sites.

Risk quotients for estuarine/marine invertebrates (based on a mysid EC_{50} of 1.7 ppb) exceed acute high risk, acute restricted use, and acute endangered species levels of concern at application rates equal to or above 1.95 lb/A. No estuarine invertebrate NOEC/MATC information is available to calculate chronic risk quotients.

d. Exposure and Risk to Nontarget Plants

No ecological risk assessment for non-target plants was required.

e. Exposure and Risk to Endangered Species

The Agency has developed a program (the "Endangered Species Protection Program") to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that will eliminate the adverse impacts. At present, the program is being implemented on an interim basis as described in a Federal Register notice (54 FR 27984-28008, July 3, 1989), and is providing information to pesticide users to help them protect these species on a voluntary basis. As currently planned, the final program will call for label modifications referring to required limitations on pesticide uses, typically as depicted in county-specific bulletins or by other site-specific mechanisms as specified by state partners. A final program, which may be altered from the interim program, will be described in a future Federal Register notice. The Agency is not imposing label modifications at this time through the RED. Rather, any requirements for product use modifications will occur in the future under the Endangered Species Protection Program.

Risk Characterization

While available data submitted by the registrant suggest that isofenphos is likely to be persistent (with half-lives in aerobic soils approaching one year, field dissipation half-lives from the soil surface approaching three months, and limited aquatic studies suggesting little or no degradation), studies published in open scientific literature indicate soil microbial adaptations are likely to lead to enhanced degradation of the chemical. Therefore, the persistence data are likely to be most applicable when isofenphos is applied for the first time. In subsequent applications, enhanced biodegradation is likely to reduce the persistence of the chemical significantly.

Such a situation complicates the ecological risk assessment for isofenphos. The LOC exceedances are based on EECs derived from submitted guideline studies that suggest persistence. These EECs are likely to be reasonable high-end estimates during the first year of application but may greatly overestimate risk in areas where enhanced biodegradation occurs. Thus, isofenphos may pose a risk to nontarget organisms in its first year of use but this risk may be significantly reduced in subsequent years due to a decrease in persistence. We should note, however, that the actual degree of enhanced degradation cannot be quantified based on our limited literature search. Neither can it be confirmed that this enhanced degradation is universal, although the scope of the phenomenon was such that it caused widespread loss of efficiency in treating corn rootworms (Racke and Coats, 1990).

Non-target Terrestrial Organisms: Isofenphos is labeled for use on ornamental trees and shrubs, turf and residential lawns, golf courses, sod farms, rights-of-way, hedgerows/fence rows, and drainage systems/ditches. Therefore, the potential exists for exposure to numerous non-target birds, mammals, and beneficial insects that directly use these sites for nesting, feeding, cover, and other activities. In addition, indirect exposure from ground spray drift is likely to contaminate and adversely affect a wide variety of habitats for non-target organisms. Chemigation of the flowable formulation can be an ecological risk, but is rarely used.

The laboratory acute toxicity data indicate isofenphos is slightly to very highly toxic to birds, moderately to highly toxic to small mammals, and highly toxic to bees. All acute and chronic LOCs are exceeded for nongranular isofenphos except birds feeding on seeds. Acute high risk LOCs are exceeded for herbivore and insectivore mammals, but not granivores. Chronic risk LOCs are also exceeded. The acute LOCs are also exceeded for the granular formulations. According to the EPA Incident Data system, ten Canadian geese were found dead or dying in residential areas. Isofenphos was reported to be the cause of death, but no quantitative analysis was conducted (N.Y. Department of Environmental Conservation). However, no evidence of mortality or adverse effect was observed in two (small pen and simulated) field studies.

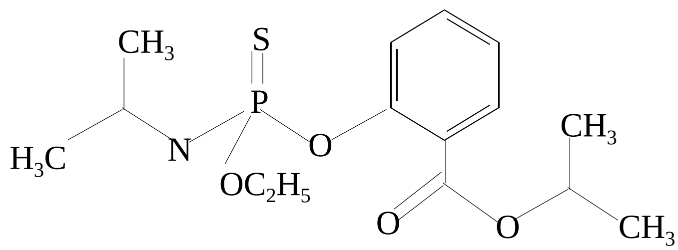
Non-target Aquatic Organisms: The laboratory acute toxicity data show that isofenphos is moderately to very highly toxic to freshwater and estuarine/marine organisms. Acute high risk and chronic LOCs are exceeded for freshwater fish only with the non-agricultural/drainage end use. No LOCs are exceeded for estuarine/marine fish at any registered end uses and application rates. Acute high risk, restricted use, endangered species, and chronic LOCs are exceeded for freshwater and estuarine invertebrates for all registered end uses and maximum application rates.

The aquatic RQs are based on Tier 1 EEC values. GENEEC may not adequately simulate the majority of isofenphos use (i.e., residential lawns), particularly due to the 10-to-1 basin-to-pond ratio and the runoff scenario (urban vs. agricultural), increasing the uncertainty in estimates. The common practice of one (ground) application with wet-in recommendation reduces the potential for runoff. The non-agricultural end uses (such as drainage ditch and right-of way) can be an ecological risk, but affected water bodies are mostly ephemeral (temporary) systems.

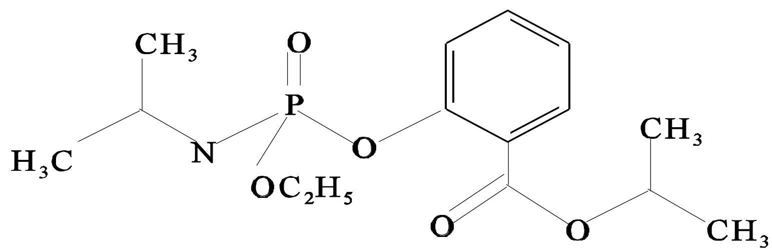
Risk may be further reduced by registered uses and label recommendations. The label recommends ground applications only and watering-in (post application irrigation to help the product reach the root zone within 24 hrs). Although a maximum of two seasonal applications is allowed, one application is a common practice. Most isofenphos usage occurs in residential areas and golf courses, over a limited acreage (approximately 132,000 acres nationally). While the limited area of use may reduce the national impact of isofenphos, it does not reduce localized risks where isofenphos is used. These localized problems will still contribute to the total organophosphate exposure.

On the other hand, the presence of isofenphos oxon, an equally toxic degradate, increases the overall risk from isofenphos use. Estimated environmental concentrations in aquatic environments for the combined residues of isofenphos and isofenphos oxon resulted in potential exposures 2-3 times greater than what has been estimated for isofenphos alone. These predicted concentrations have a high degree of uncertainty due to gaps in the fate data for isofenphos oxon. However, they show that the oxon degradate will increase the magnitude of exceedances of levels of concern resulting from the use of isofenphos.

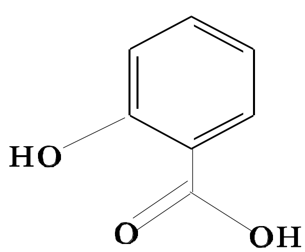
Appendix A: Isofenphos and Its Major Transformation Products



1-methylethyl 2-[[ethoxy[(1-methylethyl)-amino]-phosphinothioyl]oxy] benzoate
(Isofenphos)



1-methylethyl 2-[[ethoxy[(1-methylethyl)amino]phosphinyl]oxy]benzoate
(Isofenphos oxygen analog, aka isofenphos oxon)



Salicylic acid

Appendix B: Summary of Submitted Environmental Fate Studies

Isofenphos is a neutral, non-polar, organophosphorthioate insecticide. Laboratory analyses suggest that it is persistent and marginally mobile while terrestrial dissipation studies indicate that it is slightly mobile and less persistent in the field. All environmental fate data requirements for isofenphos have been satisfied.

Degradation

161-1 Hydrolysis

Isofenphos was stable in sterile aqueous pH 5 and 7 buffered solutions (no discernable pattern of decline in the parent chemical) and hydrolyzed only slightly (82% remaining after 30 days) in the pH 9 solution. The half-life of 131 days at pH 9 is extrapolated well beyond the 30-day study and is of questionable value for modeling purposes (MRID 419013-06).

161-2 Photolysis in Water

Isofenphos was stable to photolysis after 31 days of exposure to natural daylight at 25^{o}C in a pH 5 buffered aqueous solution. Isofenphos declined from 98% of the applied radioactivity at day 0 to 80% of the applied after 31 days of irradiation, compared to 82% of the applied in the dark controls. The half-life was 109 days for the irradiated samples and 127 days for the dark controls. Since the slight differences in the decline of isofenphos in irradiated and dark controls (2% after 31 days) is within the likely range of error in the samples, a "net photolysis" half-life was not calculated and isofenphos was considered stable to photolysis (MRID 413425-01).

161-3 Photolysis on Soil

Isofenphos was relatively stable to photodegradation on a sandy loam soil (pH 6.5; 14% clay; 1.1% organic matter) exposed to natural sunlight for 30 days. Isofenphos declined from 97% of applied radioactivity at day 0 to 32% after 30 days in the irradiated samples and to 56% in the dark control samples. The half-lives were 18 days under irradiation and 35 days in the dark, with a net photolysis half-life of 72 days. Isofenphos oxygen analog comprised 37% of the applied radioactivity after 30 days in both the irradiated and control samples, suggesting that its formation was related to something other than photolysis. Isopropyl salicylate was detected at 22% of the applied in the irradiated samples and 10% of the applied in the dark control after 30 days (MRID 413425-02).

Metabolism

162-1 Aerobic Soil Metabolism

Isofenphos degraded slowly under aerobic soil conditions with a half-life of 352 days, assuming first-order reaction kinetics. The parent chemical declined from 102% of applied radioactivity at day 1 to 46% after 366 days. After 12 months, the oxygen analog of isofenphos (isofonphos oxon) comprised 28% of the applied radioactivity while CO_2 made up 21% of the applied. Combined isofenphos and isofenphos oxon residues comrised 74% of the total residues after one year. The half-life for the combined residues was 1,044 days (MRID 429405-01).

In a supplemental study (Minor and Murphy, 1977; no MRID), isofenphos degraded with a half-life of 69 (silt loam) to 127 (sandy loam) days. However, the results of this study are of questionable value because the material balance failed to account for up to 69% of the applied radioactivity, volatiles were not measured, and study conditions were not reported. The major degradate was isofenphos oxygen analog, while up to 22% of the applied radioactivity was found in the unextracted fraction.

162-2 Anaerobic Soil Metabolism

An anaerobic aquatic metabolism study (162-3) was submitted in lieu of an anaerobic soil metabolism study.

162-3 Anaerobic Aquatic Metabolism

Isofenphos was relatively stable under anaerobic conditions (flooded loamy sand sediment in a nitrogen atmosphere), comprising of 90% of the applied radioactivity after 12 months. At the end of the study approximately 60% of the applied radioactivity was associated with the water while 30% was associated with the sediment. Minor amounts of salicylic acid ($\leq$5.6%) and isofenphos oxygen analog ($\leq$0.7%) were detected in the water and sediment extracts. Volatile residues increased to 9% after 12 months. CO_2 comprised $\leq$2% of the volatiles, while isofenphos, salicylic acid, isofenphos oxygen analog, and isopropyl salicylate were all detected in the ethylene glycol trapping solution (MRID 427280-03).

Mobility/Leachability

163-1 Batch Equilibrium

An adsorption-desorption study (MRID 414407-01) was not accepted in a 1990 EFED review (H.L. Manning, Dec. 18, 1990, Review of Phase 4 Package for Isofenphos) because the soils were sterilized with sodium azide. Studies have shown that sterilization with sodium azide can alter soil properties that influence adsorption[6]. Since previously-submitted studies showed that isofenphos was persistent under aerobic soil conditions (half-life $\geq$ 69 days) and since the equilibrium study spanned 24 hrs, sterilization was not necessary. The registrant provided data showing that the addition of 0.17% sodium azide resulted in a slight increase in soil pH (from 5.59 to 5.67 for the silt loam, 6.26 to 6.34 for the clay loam, and 6.38 to 6.54 for the sandy loam)[7]. They argued that changes in pH of the soil-water matrix would not significantly affect the

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[6] Wolf, D.C., T.H. Dao, H.D. Scott, and T.L. Lavy. 1989. Influence of sterilization methods on selected soil microbiological, physical, and chemical properties. J. Environ. Qual. 18:39-44.

[7] Thornton. 1991. Mobay response to upgrade Mobay report no. 98430 (MRID no. 41440701).

adsorption behavior of neutral, non-polar, hydrophobic organic compounds and concluded that the effect of the sodium azide sterilization on isofenphos adsorption/desorption would be minimal. The effect of sodium azide on the nature of the organic matter in the soil, particularly the functional groups, is not known. Any modifications to the structure or chemistry of the organic functional groups is likely to impact the adsorption capacity of the soil. Because of this uncertainty, the results of this study are considered supplemental.

Results from that supplemental study found that isofenphos was marginally mobile, with Freundlich K_{ads} values of 5.8 to 10.1 (n values of 0.79 to 0.92 suggest the Freundlich model may not be the best fit for adsorption of isofenphos) for four soils. K_{oc} values ranged from 663 to 1474, with an average of 972 (MRID 414407-01). The K_{ads} values correlated with the organic carbon content of the soil (r^2=0.76 for 4 values). The U.S. Department of Agriculture[8] reported K_d / K_{oc} values for isofenphos of 5.6 / 538 (silt loam) and 10.3 / 613 (sandy loam). This data is considered supplemental because of lack of information on study methods and quality control.

The isofenphos oxygen analog was mobile, with Freundlich K_{ads} values ranging from 1.5 to 3.9 (Freundlich constants 0.88 to 1.12) for four soils. K_{oc} values ranged from 150 to 308 (MRID 414407-02).

Field Dissipation

164-1 Terrestrial Field Dissipation

Dissipation of isofenphos from two turf plots (Georgia, MRIDs 423473-03, -04, -05; Minnesota, MRIDs 423658-01, -02, -03) was moderately rapid. The rate at which 50% of the pesticide dissipated from the turf and upper 6 inches of soil (DT_{50}) ranged from 14 days (GA) to 28 days (MN); calculated half-lives were 12 days (GA) and 22 days (MN). In GA, isofenphos concentrations in the turf and upper 6 inches of soil declined from a peak 0.98 ppm to 0.59 ppm at 14 days and <0.01 ppm after 119 days, while isofenphos oxygen analog (isofenphos oxon) concentrations reached a maximum of 0.33 ppm after 14 days. In MN, isofenphos concentrations in the turf and upper 6 inches of soil declined from 1.06 ppm to 0.67 ppm at 28 days and $\leq$ 0.08 ppm after 61 days. Isofenphos oxon concentrations reached a maximum of 0.33 ppm after 28 days. Neither isofenphos nor the oxon analog were detected below 12 inches in either study.

Isofenphos applied to a bare ground plot in GA (MRID 426598-02) also had a moderately rapid half life (7 days; DT_{50} of ~10 days). Isofenphos concentrations in the upper 6 inches declined from 0.57 ppm to 0.19 ppm at 14 days and <0.01 ppm after 63 days. Isofenphos oxon reached a maximum concentration of 0.23 ppm after 14 days and was not found in concentrations >0.03 ppm after 63 days. Neither isofenphos nor its oxon analog were detected below the upper 6 inches of the soil.

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[8] U.S. Department of Agriculture. 1990. Agricultural Research Service Pesticide Properties Database. Systems Research Laboratory. Reported in Montgomery, 1993. Agrochemicals Desk Reference: Environmental Data. Lewis Publishers.

Isofenphos applied to a bare ground plot in CA (MRID 426598-01) showed a biphasic dissipation pattern. The calculated half-life, assuming a first-order rate of dissipation, was 81 days. A rapid initial dissipation (DT_{50} of 7 days) was followed by a plateau between 7 and 45 days and a secondary half-life of >63 days, suggesting something other than first-order kinetics. Isofenphos declined from 2.3 ppm to 1.05 ppm (day 7) and finally to 0.01 ppm (day 553). The isofenphos oxon reached a peak of 0.42 ppm (day 182) and was detected to a maximum depth of 24-30". Isofenphos was not detected below the 12-18" layer. This study is supplemental because some samples were stored frozen for up to 307 days, 120 days longer than the length of the storage stability study submitted by the registrant (MRID 433861-01).

Table A-1. Summary of Terrestrial Field Dissipation Studies for Isofenphos.

Site/Cover	*Surface / Subsurface Soil Properties*				*Surface Dissipation, isofenphos (combined isofenphos, oxon)*		*Max. Depth of Detect*	
	%OM	*pH*	*% sand*	*% clay*	*$t_{1/2}$*	*DT_{50}*	*Isofen.*	*Oxon*
GA Turf	0.6 / 0.2-1.8	6.0 / 4.8-6.1	86 / 68-86	5 / 3-24	12 da (14 da)	14 da	6 in	12 in
GA Bareground	0.6 / 0.2-1.8	6.0 / 4.8-6.1	86 / 68-86	5 / 3-24	7 da (70 da)	10 da	6 in	6 in
MN Turf	4.9 / 0.3-2.7	7.0 / 7.0-7.4	69 / 59-93	9 / 3-17	22 da (32 da)	28 da	12 in	12 in
CA Bareground	0.3 / 0.2-0.5	7.6 / 7.2-7.4	60 / 64-78	10 / 5-8	81 da (170 da)	7/63 da	18 in	30 in

Actual isofenphos concentrations measured immediately after application in all four studies were 25 to 44% of the target maximum application rates. In some instances, 7-day concentrations were greater than those measured immediately after application. Possible explanations for this, such as loss by drift, uneven application rate, or incomplete characterization of isofenphos residues, were not explored. The studies provided no potential pathways of dissipation.

Incomplete soil information and lack of data to assess the potential leaching depth during the studies reduce the applicability of the results to broader conditions. Soil characterization data for the two Georgia studies are <u>exactly</u> the same (sample locations were not shown). Because soils are spatially variable, characterization data needs to be obtained within (or immediately adjacent to) each test plot. The soil series mapped at the test sites were not identified within the reports, precluding extrapolation to similar soils or useful correlation with soil properties. The maximum potential depth of leaching (which could be determined with a conservative tracer or predicted by water balance models) was not estimated. This would eliminate guesswork on the potential mobility of the pesticide and allow for an extrapolation of the fate assessment to broader climatic (temperature and rainfall) conditions.

An earlier field dissipation study (International Research and Development et al, 1977; reviewed by Exposure Assessment Branch, 5/25/88) summarizing 23 sites was not acceptable because of limited sampling depth (no samples >12 inches), no recovery data, and inadequate site and study characterization. Supplemental data extracted from this study found DT_{50} values from less than 2 weeks to more than a year, varying with the formulation (granular or emulsifiable concentrate), number of applications, and location. This supplemental data also implies that significant leaching of isofenphos residues below 12 inches may occur.

Bioaccumulation

165-4 Accumulation in Fish

Isofenphos residues concentrated rapidly in fish tissue, reaching plateaus within 1 to 7 days after exposure. Maximum bioconcentration factors (BCF) were 94.5X (fillet), 469X (viscera), and 277X (whole body). Depuration was rapid, with 92% (fillet), 98% (viscera), and 97% (whole body) elimination of isofenphos residues after 14 days. Based on the non-linear kinetics model, the whole body uptake rate constant was 231 $\pm$ 34, the steady-state BCF was 243 $\pm$ 51, and the time to reach 90% of the maximum BCF was 2.4 $\pm$ 0.4 days. The calculated depuration constant was 0.95 $\pm$ 0.14 and the time to reach 50% clearance of isofenphos from whole body tissue was 0.73 $\pm$ 0.11 days (MRID 419092-02).

Metabolites identified in the viscera or the fillet that accounted for 2 to 15% of the total radioactivity were isopropyl salicylate glucuronide, isofenphos oxygen analog, hydroxy isofenphos glucuronide, isopropyl salicylate sulfate, and isopropyl salicylate (MRID 423059-01).

Appendix C: Detailed Ecological Toxicity Data

a. Toxicity to Non-target Terrestrial Animals

i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of isofenphos to birds. The preferred test species is either mallard duck (a waterfowl) or bobwhite quail (an upland gamebird). Table C-1 summarizes available core and supplemental studies for acute oral toxicity studies while Table C-2 summarizes subacute toxicity studies. The guidelines 71-1 (MRID 099080) and 71-2 (MRIDs 096659, 41901305) are fulfilled with these studies.

Table C-1: Avian Acute Oral Toxicity

Species	% ai	LD50 (mg/kg)	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	92	8.7	Very Highly Toxic	099080 Lamb/79	Core
Mallard duck *(Anas platyrhynchos)*	92	32	Highly Toxic	099080 NA /79	Supplemental

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

Table C-2: Avian Subacute Dietary Toxicity

Species	% ai	5-Day LC50 (ppm)[1]	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	92	145	Highly toxic	096659 Nelson & Burke/77	Core
Mallard duck *(Anas platyrhynchos)*	92	>1000	Slightly toxic	096659 Lamb & Burke/77	Core
Mallard duck (*Anas platyrhynchos)*	91.4	4908	Slightly toxic	41901305 Stafford /91	Core

[1] Test organisms observed an additional three days while on untreated feed.

ii. Birds, Chronic

Avian reproduction studies using the TGAI are required for isofenphos because the following conditions are met: (1) birds may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season, (2) the pesticide is stable in the environment to the extent that potentially toxic amounts may persist in animal feed, (3) the pesticide is stored or accumulated in plant or animal tissues, and/or, (4) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product. The preferred test species are mallard duck and bobwhite quail. The guideline (71-4) is fulfilled (MRIDs 098035, 098036, 42347301, 42891701).

Table C-3: Avian Reproduction

Species	% ai	NOEC/LOEC (ppm)	LOEC Endpoints	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	91.9	25/50	Reproductive success % hatch of embryo	098035 Beavers/81	Core
Northern bobwhite quail *(Colinus virginianus)*	91.4	50/100	Reproductive effects egg/ laid/hatched, viable embryo	42347301 Beavers et al. /92	Core
Mallard duck *(Anas platyrhynchos)*	92	NA/150 (LOEC)	Reproductive success 14-d old survivor of egg set & normal hatchling	098036 Beavers /81	Core
Mallard duck *(Anas platyrhynchos)*	91.4	10/75	Body weight	42891701 Beavers et al./92	Core

NA Not available

iii. Mammals, Acute and Chronic

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's Health Effects Division (HED) substitute for wild mammal testing. EFED has not guideline requirement for these studies.

Table C-4: Mammalian Toxicity

Species	% ai	Test Type	Toxicity Value	Affected Endpoints	MRID No.
laboratory rat *(Rattus norvegicus)*	Tech.	Acute oral	LD50 28-38 mg/kg	Mortality	Not available
Laboratory mouse *(Mus musculus)*	Tech	Acute oral	LD50 91.3-127 mg/kg	Mortality	Not available
laboratory rat *(Rattus norvegicus)*	Tech	2-year feeding & oncogenic	NOEL 1 ppm	No oncogenic response	Not available
laboratory rat (*Rattus norvegicus*)	Tech	3-generation reproduction	NOEL 1 ppm	ChE inhibition	Not available

iv. Insects

A honey bee acute contact study using the TGAI is required for isofenphos because its use (ornamental plants, lawn and turfs) will result in honey bee exposure. The guideline (141-1) is fulfilled (MRID 42567701). A honey bee toxicity of residues on foliage study using the typical end-use product is required for Isofenphos because its use (ornamental turf and plant) will result in honey bee exposure and the acute contact honey bee LD50 is less than 0.1 *ug*/bee. No honey bee residual toxicity study is submitted.

Table C-5: Nontarget Insect Acute Contact Toxicity

Species	% ai	LD50 (μg/bee)	Toxicity Category	MRID No. Author/Year	Study Classification
Honey bee *(Apes mellifera)*	91.9	0.052278	Highly toxic	42567701 Mayer/92	Core

v. Terrestrial Field Testing

a) Avian Small Pen Study of Amaze 20 G with Bobwhite Quail (Carlisle & Carsel, 1982; Acc. # 248344): No evidence of mortality or other adverse effects from exposure to application of Amaze 20% Granules at up to 1.3 lb. a.i./acre was found. This study is scientifically sound and will support the requirement for a small pen field study on a wild upland game species.

b) Simulated Field Study with Amaze 5% Granular on Turf with Rabbits and Bobwhite Quail (Lamb, 1981; Acc. #31255-323): Amaze 5 granular did not cause any hazard to rabbit and quail at 2 lb. a.i./A.

b. Toxicity to Freshwater Aquatic Animals

i. Freshwater Fish, Acute

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of isofenphos to fish. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warmwater fish). The guideline (72-1) is fulfilled (MRID 096659, 41901303, 41901304).

Table C-6: Freshwater Fish Acute Toxicity

Species/ (Flow-through or Static)	% ai	96-hour LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)* static	92	1.8	Moderately toxic	096659 Nelson & Roney/77	Core
Rainbow trout *(Oncorhynchus mykiss)* static	91.8	3.3	Moderately toxic	41901304 Gagliano/91	Suppl.
Bluegill sunfish *(Lepomis macrochirus)*	92	1.4	Moderately toxic	096659 Nelson & Roney /77	Core
Bluegill sunfish *(Lepomis macrochirus)*	91.8	2.2	Moderately toxic	41901303 Gagliano	Core
Channel catfish (*Ictalurus punctatus*)	92	2.1	Moderately toxic	096659 Nelson & Roney /77	Core
Bluegill sunfish *(Lepomis macrochirus)*	15	15	Slightly toxic	096659 Nelson & Roney/77	Suppl.
Bluegill sunfish *(Lepomis macrochirus)*	72	1.3	Moderately toxic	096659 Nelson & Roney/77	Suppl.

Table C-6: Freshwater Fish Acute Toxicity

Species/ (Flow-through or Static)	% ai	96-hour LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)* static	15	20	Slightly toxic	096659 Nelson & Roney/77	Suppl.
Rainbow trout *(Oncorhynchus mykiss)* static	72	2	Moderately toxic	096659 Nelson & Roney/77	Suppl.

ii. Freshwater Fish, Chronic

A freshwater fish early life-stage test using the TGAI Is required for isofenphos because the end-use product is likely to be transported to water from the intended use site, and the EEC in water is greater than 0.01 of any acute LC_{50} or EC_{50} value and the pesticide is likely to be persistent in water. The preferred test species is rainbow trout. The guideline (72-4) is fulfilled (MRID 41909201).

Table C-7: Freshwater Fish Early Life-Stage Toxicity Under Flow-through Conditions

Species	% ai	NOEC/LOEC (ppb)	MATC (ppb)	Endpoint Affected	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)*	91.9	153/ >407	250	Larval mortality & growth	126777 Carlisle/Roney/83	Core
Rainbow trout *(Oncorhynchus mykiss)*	91.9	NOEC=1563 (highest conc)	-	Hatching larval mortality	126775 Carlisle/Roney/83	Core
Rainbow trout *(Oncorhynchus mykiss)*	91.9	66/206	117	Larval mortality	109276 Carlisle /82	Core
Fathead minnows *(Pimephales promelas)*	91.8	61/130	89	Growth (length)	41909201 Rhodes & Herzig/91	Core

MATC defined as the geometric mean of the NOEC and LOEC. NA Not available

A freshwater fish life-cycle test using the TGAI is required for isofenphos because the end-use product is intended to be applied directly to water or is expected to be transported to water from the intended use site, and the following conditions are met: (1) the EEC is greater than one-tenth of the NOEL in the fish early life-stage or invertebrate life-cycle test. No freshwater fish life-cycle toxicity study is submitted. However, the study will be waived because both freshwater fish acute high risk and chronic LOCs are not exceeded for all end uses except for ornamental trees and non-agricultural ditch (for acute risk only).

iii. Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of isofenphos to aquatic invertebrates. The preferred test species is *Daphnia magna*. The guideline (72-2) is fulfilled (MRID 099081, 096659, 41609908).

Table C-8: Freshwater Invertebrate Acute Toxicity

Species	% ai	48-hour LC50/ EC50 (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	92	3.9	Very highly toxic	099081 Nelson/79	Core
Waterflea *(Daphnia magna)*	Tech.	4.6	Very highly toxic	096659 Nelson & Burke/77	Suppl.
Waterflea *(Daphnia magna)*	22.7	4.3	Very highly toxic	41609908 Heimback/90	Core

iv. Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle test using the TGAI is required for isofenphos since the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) any aquatic acute LC_{50} or EC_{50} is less than 1 mg/l, and (2) the EEC in water is equal to or greater than 0.01 of any acute EC_{50} or LC_{50} value and the pesticide is likely to be persistent in water. The preferred test species is *Daphnia magna*. The guideline (72-4) is fulfilled (MRID 43220002, 41609907).

Table C-9: Freshwater Aquatic Invertebrate Life-Cycle Toxicity

Species	% ai	21-day NOEC/ LOEC (ppb)	MATC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	98.1	>0.50/<0.99	0.70	Surviving offsprings & growth	43220002 Gagliano/93	Core
Waterflea *(Daphnia magna)*	91.5	NA/0.22	-	Surviving offsprings	41609907 Thacker/90	Suppl.

[1] defined as the geometric mean of the NOEC and LOEC. NA Not available

c. Toxicity to Estuarine and Marine Animals

i. Estuarine and Marine Fish, Acute

Acute toxicity testing with estuarine/marine fish using the TGAI is required for Isofenphos because the end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species is sheepshead minnow. The guideline (72-3a) is fulfilled (MRID 42321801).

Table C-10: Estuarine/Marine Fish Acute Toxicity

Species	% ai	96-hour LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow *(Cyprinodon variegatus)*	91.9	1.66	Moderately toxic	42321801 Gagliano /92	Core

ii. Estuarine and Marine Fish, Chronic

An estuarine/marine fish early life-stage test using the TGAI Is required for isofenphos because the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: the EEC in water is greater than 0.01 of any acute LC_{50} or EC_{50} value and the pesticide is persistent in water. The preferred test species is sheephead minnow.

No estuarine and marine fish chronic toxicity study was submitted. However, the study will be waived because both freshwater acute high risk and chronic LOCs are not exceed for all end uses except ornamental trees and non-agricultural ditch.

An estuarine/marine fish life-cycle test using the TGAI is required for isofenphos because the end-use product is intended to be applied directly to water or is expected to transport to water from the intended use site, and the following conditions are met: (1) the EEC is equal to or greater than one-tenth of the NOEC in the fish early life-stage or invertebrate life-cycle test, or, (2) studies of other organisms indicate the reproductive physiology of fish may be affected. The preferred test species is sheepshead minnow. The estuarine/marine fish life-cycle study is not submitted. However, the study will be waived because both freshwater acute high risk and chronic LOCs are not exceed for all end uses except (ornamental trees and non-agricultural ditch).

iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the TGAI is required for Isofenphos because the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species are mysid and eastern oyster. The guideline (72-3b and 72-3c) is fulfilled (MRID 416099-09,-10).

Table C-11: Estuarine/Marine Invertebrate Acute Toxicity

Species	% ai.	96-hour LC_{50}/EC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Eastern oyster (shell deposition or embryo-larvae) *(Crassostrea virginica)*	90.1	0.152	Highly toxic	41609910 Dionne/90	Core
Mysid *(Americamysis bahia)*	90.9	0.0017	Very highly toxic	41609909 Sousa/90	Core

iv. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle toxicity test using the TGAI is required for isofenphos because the end-use product may be applied directly to the estuarine/marine environment or expected to be transported to this environment from the intended use site, and the following conditions are met: (1) any aquatic acute LC_{50} or EC_{50} is less than 1 mg/l, (2) the EEC in water is equal to or greater than 0.01 of any acute LC_{50} or EC_{50} value, and (3) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute LC_{50} or

EC_{50} value and any of the following conditions exist: studies of other organisms indicate the reproductive physiology of fish and/or invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water. The preferred test species is mysid. No estuarine/marine invertebrate toxicity study was submitted.

Appendix D: Risk Quotients

A means of integrating the results of exposure and ecotoxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic:

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** - potential for acute risk is high, regulatory action may be warranted in addition to restricted use classification (2) **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification (3) **acute endangered species** - the potential for acute risk to endangered species is high, regulatory action may be warranted, and (4) **chronic risk** - the potential for chronic risk is high, regulatory action may be warranted. EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess acute effects are: (1) LC50 (fish and birds) (2) LD_{50} (birds and mammals (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEC (birds, fish, and aquatic invertebrates) (2) NOEC (birds, fish and aquatic invertebrates) and (3) MATC (fish and aquatic invertebrates). For birds and mammals, the NOEC value is used as the ecotoxicity test value in assessing chronic effects. Other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the ecotoxicity test value in assessing chronic effects to fish and aquatic invertebrates. However, the NOEC is used if the measurement end point is production of offspring or survival.

Table D-1: Risk Presumptions for Non-Target Organisms, with Corresponding RQs and LOCs.

Risk Presumption	RQ	LOC
	Birds	
Acute High Risk	EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3]	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOEC	1
	Wild Mammals	
Acute High Risk	EEC/LC50 or LD50/sqft or LD50/day	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOEC	1

Table D-1: Risk Presumptions for Non-Target Organisms, with Corresponding RQs and LOCs.

Risk Presumption	RQ	LOC
	Aquatic Animals	
Acute High Risk	EEC[3]/LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC/MATC or NOEC	1
	Terrestrial and Semi-Aquatic Plants	
Acute High Risk	EEC[4]/EC25	1
Acute Endangered Species	EEC/EC05 or NOEC	1
	Aquatic Plants	
Acute High Risk	EEC[5]/EC50	1
Acute Endangered Species	EEC/EC05 or NOEC	1

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

[2] $\frac{\text{mg/ft}^2}{\text{LD50 * wt. of bird}}$ [3] $\frac{\text{mg of toxicant consumed/day}}{\text{LD50 * wt. of bird}}$

[3] EEC = (ppm or ppb) in water [4] EEC = lbs ai/A [5] EEC = (ppb/ppm) in water

a. Exposure and Risk to Nontarget Terrestrial Animals

i. Birds

a. Non-granular Products

The acute risk quotients for broadcast applications of nongranular products are tabulated below.

Table D-2: Avian Acute and Chronic Risk Quotients for Multiple Applications of Nongranular Products (Broadcast) Based on a bobwhite quail LC50 of 145 ppm and a mallard duck NOEC of 10 ppm .

Site/App. Method App. Rate (lbs ai/A) x No. of Apps.	Food Items	Maximum EEC[1] (ppm)	LC50 (ppm)	NOEC (ppm)	Acute RQ (EEC/ LC50)	Chronic RQ (EEC/ NOEC)
Turf / Chemigation 2 x 2	Short grass	888	145	10	6.12***	88.80+
	Tall grass	407	145	10	2.81***	40.70+
	Broadleaf plants/Insects	500	145	10	3.45***	50.00+
	Seeds	56	145	10	0.39**	5.60+

1 Assumes degradation using FATE program.
*** exceeds acute high risk, restricted use, and endangered species LOC
** exceeds acute high risk, restricted use LOC
\+ exceeds chronic risk for reproduction effect

b. Granular Products

Birds may be exposed to granular pesticides ingesting granules when foraging for food or grit. They also may be exposed by other routes, such as by walking on exposed granules or drinking water contaminated by granules. The number of lethal doses (LD_{50}s) that are available within one square foot immediately after application ($LD_{50}s/ft^2$) is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight class of birds: 1000 g (e.g., waterfowl), 180 g (e.g., upland gamebird) and 20 g (e.g., songbird).

Table D-3: Avian Risk Quotients for Granular Products (Broadcast) Based on a bobwhite quail LD50 of 8.7 mg/kg and mallard duck LD50 of 32 mg/kg .

Site/ Application Method/Rate in lbs ai/A	Fraction of Pesticide Left on Surface	Body Weight (g)	LD50 (mg/kg)	Acute RQ ($LD50/ft^2$)
Turf/Unincorporated / 2 lb ai/A	1.0	20	-	??
	1.0	180	8.7	13.28***
	1.0	1000	32	0.65***

[1] RQ = $\frac{\text{App. Rate (lbs ai/A)} * (453{,}590 \text{ mg/lbs}/43{,}560 \text{ ft}^2/\text{A})}{\text{LD50 mg/kg} * \text{Weight of Animal (g)} / 1000 \text{ g/kg}}$

*** exceeds acute high risk, restricted use, and endangered species LOC

ii. Mammals

Estimating the potential for adverse effects to wild mammals is based upon EEB's draft 1995 SOP of mammalian risk assessments and methods used by Hoerger and Kenaga (1972) as modified by Fletcher *et al*. (1994). The concentration of isofenphos in the diet that is expected to be acutely lethal to 50% of the test population (LC_{50}) is determined by dividing the LD_{50} value (usually rat LD_{50}) by the fraction of body weight consumed. A risk quotient is then determined by dividing the EEC by the derived LC_{50} value. Risk quotients are calculated for three separate weight classes of mammals (15, 35, and 1000 g), each presumed to consume four different kinds of food (grass, forage, insects, and seeds).

a. Non-granular Products

Table D-4: Mammalian (Herbivore/Insectivore) Acute Risk Quotients Multiple Applications of Nongranular Products (Broadcast) Based on a rat LD50 of 28 mg/kg.

Site/ App. Method/ Rate in lbs ai/A (No. of Apps.)	Body Wt. (g)	% Body Wt Consumed	EEC (ppm) Short Grass	EEC (ppm) Forage & Small Insects	EEC (ppm) Large Insects	Acute RQ[1] Short Grass	Acute RQ Forage & Small Insects	Acute RQ Large Insects
Turf / Chemigation 2 (2)	15	95	960	540	60	32.57****	18.32***	2.04***
	35	66	960	540	60	22.63***	12.73***	1.41***
	1000	15	960	540	60	5.14***	2.89***	0.32**

Table D-5: Mammalian (Granivore) Acute Risk Quotients for Multiple Applications of Nongranular Products (Broadcast) Based on a rat LD50 of 28 mg/kg .

Site/ App. Method/ Rate (No. of Apps.)	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	EEC (ppm) Seeds	Acute RQ[1] Seeds
Turf / Chemigation 2 lb ai/A (2)	15	21	28	60	0.45**
	35	15	28	60	0.32**
	1000	3	28	60	0.06

[1] RQ = $\frac{\text{EEC (ppm)}}{\text{LD50 (mg/kg)/ \% Body Weight Consumed}}$

*** exceeds acute high risk, restricted use, and endangered sp. LOCs
** exceeds restricted use, and endangered sp. LOC

The chronic risk quotients for multiple broadcast applications of nongranular products assuming degradation using FATE program are tabulated below.

Table D-6: Mammalian Chronic Risk Quotients for Multiple Applications of Nongranular Products (Broadcast) Based on rat NOEC of 1 ppm in a oncogenic and reproduction studies.

Site/Application Method/ Rate (No. of Apps.)	Food Items	Max. EEC[1] (ppm)	Ave. EEC[1,2] (ppm)	Chronic RQ Max. EEC/NOEC)	Chronic RQ (Ave. EEC/NOEC)
Turf / Chemigation 2 lb ai/A (2)	Short grass	888	458	888***	458 ***
	Tall grass	407	210	407***	210 ***
	Broadleaf plants/Insects	500	258	500***	258 ***
	Seeds	56	30	56 ***	30 ***

[1] Assumes degradation using FATE program.
[2] Average residues during time from first to last application.
*** exceeds acute high risk, restricted use, and endangered sp. LOC

b. Granular products

Mammalian species also may be exposed to granular/bait pesticides by ingesting granules. They also may be exposed by other routes, such as by walking on exposed granules and drinking water contaminated by granules. The number of lethal doses (LD50's) that are available within one square foot immediately after application can be used as a risk quotient ($LD50's/ft^{2}$) for the various types of exposure to bait pesticides. Risk quotients are calculated for three separate weight classes of mammals: 15 g, 35 g and 1000 g. The acute risk quotients for broadcast applications of granular products are tabulated below.

Table D-7: Mammalian Acute Risk Quotients for Granular Products (Broadcast) Based on a rat LD50 of 28 mg/kg.

Site/ Application Method/ Rate in lbs ai/A	Fraction Pesticide Left on Surface	Body Weight (g)	Rat LD50 (mg/kg)	Acute RQ[1] ($LD50/ft^2$)
Turf / Ground 2	1.0	15	28	49.52***
	1.0	35	28	21.22***
	1.0	1000	28	0.74***

[1] RQ = $\frac{\text{App. Rate (lbs ai/A) * (453,590 mg/lbs/43,560 ft}^2\text{/A)}}{\text{LD50 mg/kg * Weight of Animal (g) / 1000 g/kg}}$
*** exceeds acute high risk, restricted use, and endangered sp. LOC

Currently, EFED does not have a standard procedure for assessing chronic risk to mammalian species for granular products.

iii. Insects

Currently, EFED does not assess risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions.

b. Exposure and Risk to Nontarget Freshwater Aquatic Animals

i. Freshwater Fish

Acute and chronic risk quotients are tabulated below.

Table D-8: Risk Quotients for Freshwater Fish Based On a rainbow trout LC50 of 168 ppb and NOEC of 66 ppb.

Site (Formulation) Rate (No. Apps.)	LC50 (ppb)	NOEC (ppb)	EEC Peak (ppb)	EEC 56-Day Ave. (ppb)	Acute RQ (EEC/LC50)	Chronic RQ (EEC/NOEC)
Turf (EC) 2 lb ai/A (2)	1400	66	52	37	0.04	0.56
Turf / Ornamental (G) 2 lb ai/A (2)	1400	66	50	36	0.04	0.55
Non-Ag./ditch (G) 2 lb ai/A (2)	1400	66	230	165.6	0.16**	2.51+

*** exceeds acute high risk, restricted use, and endangered species LOC + exceeds chronic effects LOC
** exceeds restricted use, and endangered species LOC

ii. Freshwater Invertebrates

The acute and chronic risk quotients are tabulated below.

Table D-9: Risk Quotients for Freshwater Invertebrates Based On a Daphnid EC_{50}/LC_{50} of 3.9 ppb and LOEC of 0.22 ppb.

Site (Formulation) Rate in lbs ai/A (No. of Apps.)	LC50 (ppb)	NOEC/ MATC (ppb)	EEC Peak (ppb)	EEC 21-Day Average (ppb)	Acute RQ (EEC/LC50)	Chronic RQ (EEC/ NOEC or MATC)
Turf (EC) / 2 (2)	3.9	0.22	52	44	13.33***	200+
Turf / Ornamental (G) / 2 (2)	3.9	0.22	50	43	12.82***	195.45+
Non-Ag./ditch (G) 2 (2)	3.9	0.22	230	198	58.97***	900+

*** Exceeds acute high risk, restricted use, and endangered species LOC + Exceeds chronic effect LOC

c. Estuarine and Marine Animals

The acute and chronic risk quotients are tabulated below.

Table D-10: Risk Quotients for Estuarine/Marine Fish Based on a sheephead minnow LC50 of 1660 ppb and a sheephead minnow NOEC of 61 ppb .

Site (Formulation) Rate in lbs ai/A (No. of Apps.)	LC50 (ppb)	NOEC/ MATC (ppb)	EEC Peak (ppb)	EEC 56-Day Average	Acute RQ (EEC/LC50)	Chronic RQ (EEC/NOEC or MATC)
Turf (EC) 2 (2)	1660	61	52	3714	0.03	0.61
Turf / Ornamental (G) 2 (2)	1660	61	50	36	0.03	0.59
Non-Ag./ditch (G) 2(2)	1660	61	230	165.6	0.14 **	2.71+

** exceeds restricted use, and endangered sp. LOC + exceeds chronic effect LOC

Table D-11: Risk Quotients for Estuarine/Marine Aquatic Invertebrates Based on a mysid shrimp EC50 of 1.7 ppb.

Site (Formulation) Rate in lbs ai/A (No. Apps.)	LC50 (ppb)	NOEC/ MATC (ppm)	EEC Peak (ppm)	EEC 21-Day Average	Acute RQ (EEC/LC50)	Chronic RQ (EEC/NOEC or MATC)
Turf (EC) 2 (2)	1.7	-	52	44	30.59***	-
Turf / Ornamental (G) 2 (2)	1.7	-	50	43	29.4***	-
Non-Ag./ditch (G) 2(2)	1.7	-	230	198	135.29***	-

*** exceeds acute high risk, restricted use, and endangered sp. LOC